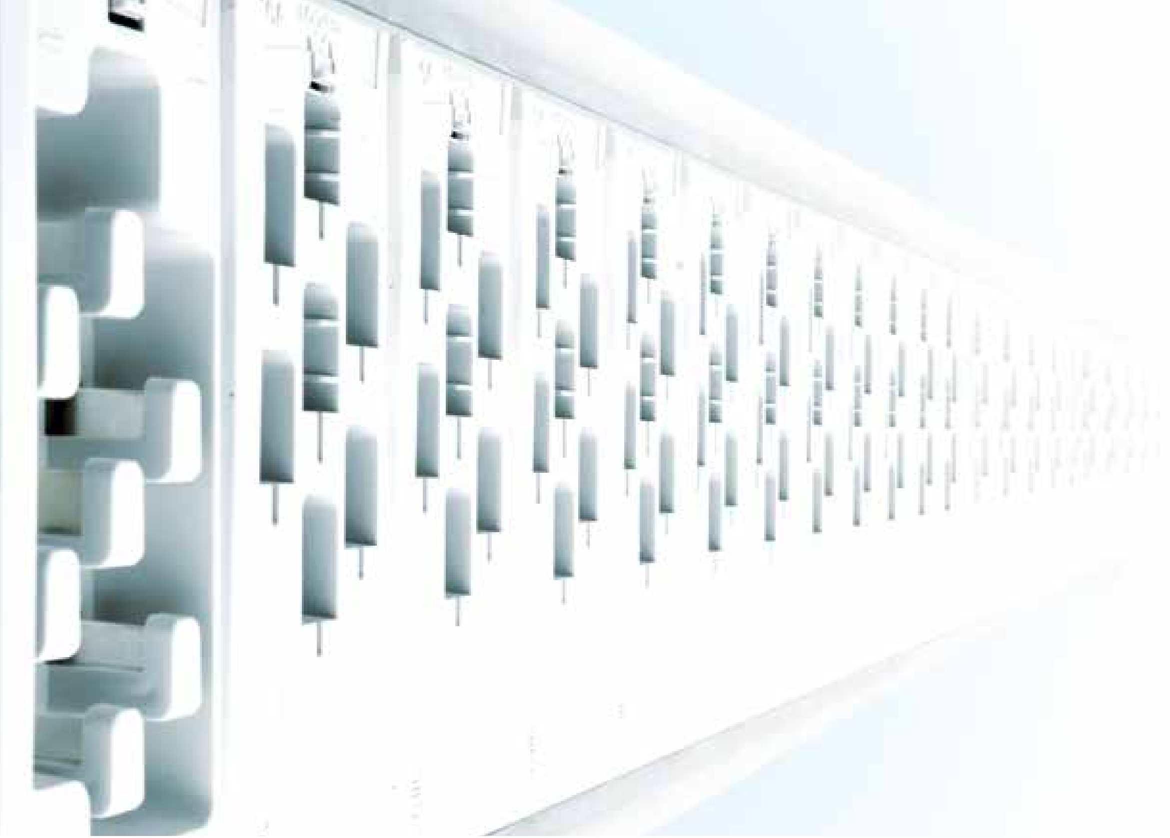


Guide to
Specifying Prefabricated Wiring Systems

Introduction

Prefabricated wiring systems may be referred to in generic terms as: “modular wiring” or “plug and play”. However, the key question for any prefabricated wiring system is, does it comply with the appropriate safety requirements as a complete system?

This guide expands upon some of the key requirements when specifying prefabricated wiring systems, such as system safety standards and achieving conformity with BS 7671 (Wiring Regulations).

You should be aware that this guide does not ensure compliance with legal requirements, standards or regulations.
You should always consult the relevant documents to ensure compliance.

Contents

The need for a system safety standard	Page 4
System safety standard specification	Page 6
Competency to certify conformity with BS 8488	Page 7
Application of the system	Page 8
System design to BS 7671	Page 9
System distribution board	Page 20
Area Distribution Box	Page 21
Lighting Distribution Unit	Page 22
Installation couplers	Page 24

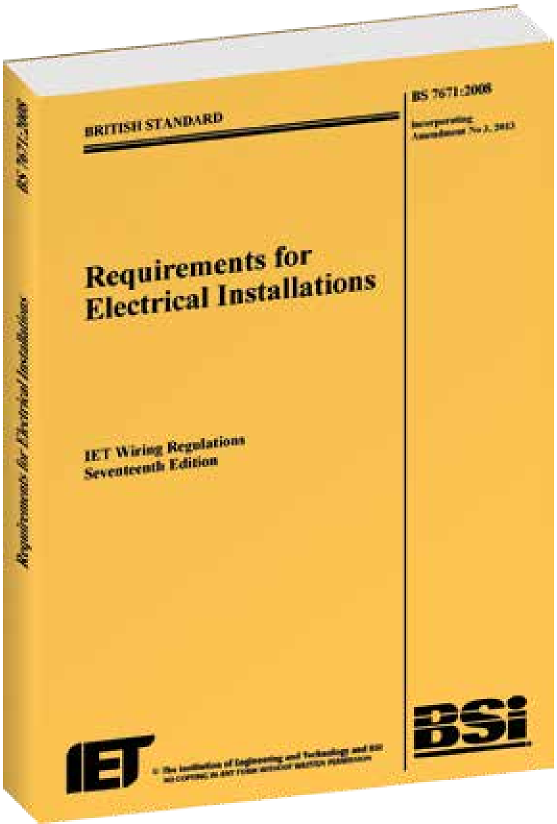
The need for a safety standard

Specifiers and installers have, for a number of years, been keen to exploit the benefits of prefabricated wiring systems as an alternate to conventional fixed wiring methods.

Some prefabricated wiring systems have been associated with serious safety issues. Reversed polarity, under rated couplers and incorrectly sized wiring sections have been areas of concern.

The absence of a system standard that specified safety requirements, together with associated testing, was discussed by the technical committee responsible for the BS 7671 (Wiring Regulations). It was agreed that there was a need for a Product Standard. Consequently, the appropriate BSI committee developed a new British Standard: BS 8488-1, which was published February 2009 and amended November 2010 to become: BS 8488:2009+A1:2010. In this guide, reference to BS 8488 means BS8488:2009+A1:2010.

"Some prefabricated wiring systems have been associated with serious safety issues".



BS 8488 is specified in BS 7671 under section 521; types of wiring system.

Regulation 521.201 states:
Prefabricated wiring systems intended for permanent connection in fixed installations incorporating installation couplers conforming to BS EN 61535, shall comply with BS 8488.

Importantly, appendix 1, which lists British Standards to which reference is made in the Regulations, identifies the 2010 version of BS 8488 as the appropriate version to specify.

"BS 8488 is specified in the 17th Edition of the IET Wiring Regulations".

System safety standard specification

BS 7671 recognises equipment complying with an appropriate British Standard or Harmonised Standard without further qualification. This approach means that the person responsible for specifying the prefabricated wiring system must, identify the “appropriate” standard.

BS 8488 specifies safety requirements, together with associated tests, for prefabricated wiring systems incorporating installation couplers conforming to BS EN 61535 (BS EN 61535 has replaced BS 61535).

Some key safety requirements and tests prescribed in BS 8488 are:

- Protection against electric shock
- Insulation resistance and electric strength
- Clearances and creepage distances
- Resistance to heat, fire and tracking
- Routine tests (during and/or after manufacture)

“BS 8488 specifies safety requirements, together with associated tests, for prefabricated wiring systems”.

Competency to certify conformity with BS 8488

One aspect that must not be overlooked by the person responsible for specifying the prefabricated wiring system is evidence of competency to test and issue certificates of conformity. This can be overcome, by specifying that the laboratory must, be independently recognized to BS EN ISO/IEC 17025 for BS 8488 (see figure 1).

“A laboratory, independently recognized to BS EN ISO/IEC 17025 provides evidence of competency”.

BS EN ISO/IEC 17025:2005 and REGULATIONS FOR ASTA RECOGNIZED LABORATORIES

COMPANY: Hager Engineering

SCOPE: BS 8488

Figure 1 - Example of a laboratory that is independently assessed to BS 8488.

Application of the system

BS 8488 identifies that prefabricated wiring systems are for permanent connection in fixed installations and the associated installation couplers are intended to be engaged or disengaged during first installation, during maintenance or during re-configuration of the installation. Prefabricated wiring systems are intended to be installed by instructed or skilled persons, including the connection and disconnection of installation couplers.

Prefabricated wiring systems can be used in suspended floors and ceilings, which are commonly used in buildings or structures. By using prefabricated wiring systems, the installation work becomes quicker than using traditional methods as they are designed to provide rapid & correct connection. An example is where separate luminaires can be easily linked to form a comprehensive lighting system by using a prefabricated wiring system (see figure 2).

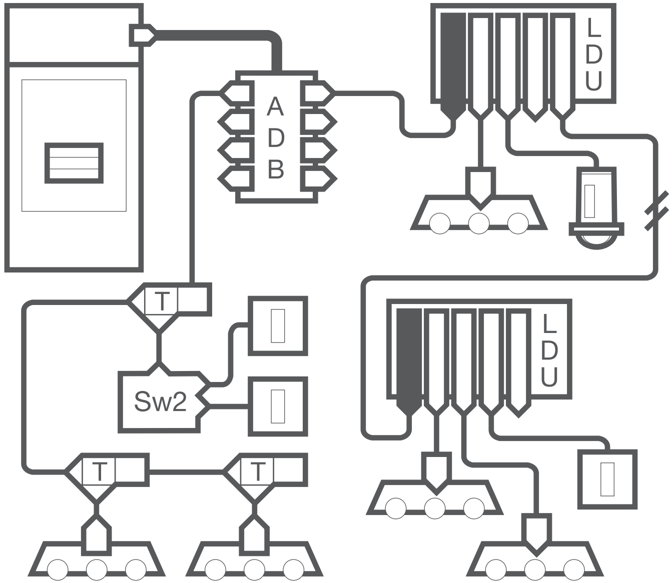


Figure 2 - Comprehensive lighting system using a prefabricated wiring system.

System design to BS 7671

BS 8488 requires the following details to be provided with each prefabricated wiring section, if they are necessary to ensure safe use and maintenance:

- Instructions for safe use
- System design information, validating conformity with BS 7671. The information can be a system design and not provided with each wiring section
- Information required to facilitate inspection and testing for conformity with BS 7671. The information can be for the complete system and not provided with each wiring section.

Prefabricated wiring systems are an alternative to conventional fixed wiring methods; however, BS 8488 identifies the need for system design, installation & verification for conformity with BS 7671. Design elements of the system to be verified for conformity with BS 7671, includes the following fundamentals:

"If necessary to ensure safe use and maintenance, system design information validating conformity with BS 7671 and information to facilitate inspection and testing for conformity with BS 7671 shall be provided".

Fundamentals in the BS 7671 design process (this list is not exhaustive)

Design current

The design current for discharge lighting must take into account control gear losses and harmonic current.

Overcurrent protective devices

The characteristics of the overcurrent protective device must take into account inrush and starting currents e.g. those associated with transformers and discharge lighting.

"BS 8488 requires the rated current to be marked on each section".

Cross-sectional area of live conductors

BS 8488 prescribes that the rated current shall be assigned according to a reference method defined by the manufacturer from BS 7671:2008, Table 4A2. Also, the rated current and cross-sectional area of the wiring section conductors shall be determined on the following basis:

- The number of loaded cores defined by the manufacturer. A loaded core is where the conductor carries more than 30% of its rating, after applying the rating factor for the total number of current carrying cores
- Not being grouped with other wiring systems or cables
- Not being in contact with thermal insulation
- The ambient temperature not exceeding 30 °C
- The frequency of operating being not greater than 61 Hz.

"The required current-carrying capacity of a system section should be determined by the system disgner, by applying relevant rating factors".

Marking of a wiring section rated current

BS 8488 requires the rated current (A) and corresponding reference method from BS 7671:2008, Table 4A2 to be distinctly and durably marked on each individual section (see figure 3.).

BS 8488 states that the required current-carrying capacity of a system section should be determined by the system designer by applying rating factors for the specific installation conditions. This current carrying capacity may be different from the rated current.

All applicable rating factors must be applied, including those for grouping, ambient temperature and thermal insulation. Assuming overload protection and simultaneous overload can occur, this would be the familiar equation from BS 7671 appendix 4 shown in figure 4.

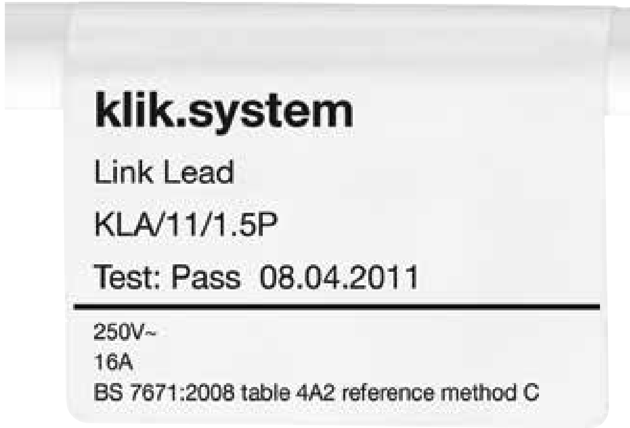


Figure 3 - Example of rated current marking on each individual section.

$$I_t \geq \frac{I_n}{C_g\, C_a\, C_s\, C_d\, C_i\, C_f\, C_c}$$

Figure 4 - Equation 2 from BS 7671 appendix 4 to determine the size of cable to be used.

Note: Not all rating factors would necessarily apply and other equations may be suitable

Current-carrying capacity & Loaded core factor

BS 8488 identifies that prefabricated wiring systems may employ flexible cables. It should be noted that the calculations related to flexible cables require particular attention.

The current-carrying capacities tabulated in appendix 4 of BS 7671 are based on cables having solid conductors (Class 1), or stranded conductors (Class 2), except for Tables 4F1A to 4F3B. Therefore, to obtain the correct current-carrying capacity for cable types similar to those covered by Tables 4D1, 4D2, 4E1 and 4E2 but with flexible conductors (Class 5), the tabulated values in 4D1 etc are multiplied by factors. The factor for up to and including $16mm^2$ is shown in table 1.

An important design aspect identified by BS 8488 is the loaded core factor, which is critical to the correct design of say a multicore SWA cable used for home runs.

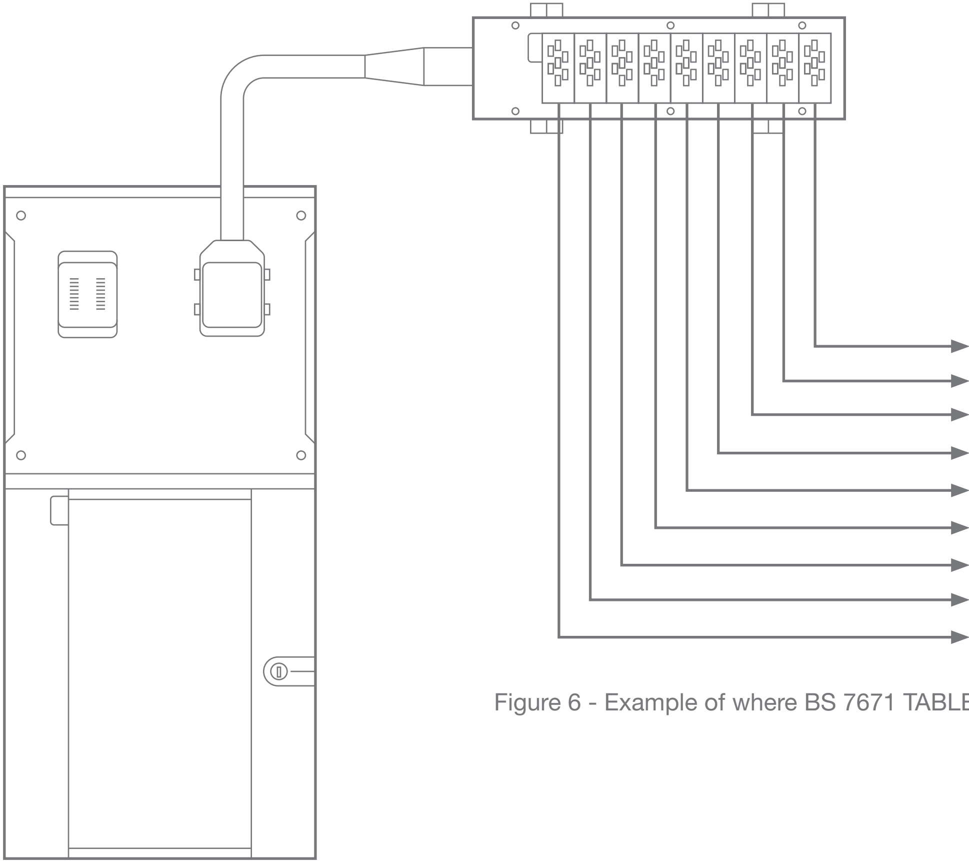
Cable Size	Current-carrying capacity factor
≤ $16.0mm^2$	0.95

Table 1 Current-carrying capacity factor

A loaded core is where the conductor carries more than 30% of its rating, after applying the rating factor for the total number of current carrying cores.

This was first addressed in amendment 1 to BS 7671: 2008 with the introduction of TABLE 4B5 – Rating factors for cables having more than 4 loaded cores and the equation: $I_{zlc} = I_{t2c} \times C_{gN}$. It is important to note, that for single phase circuits, more than "**3** loaded cores" applies; regulations 523.6.1 and 523.6.2 refer.

This means that the current carrying capacity of the multicore cable is derived by applying the rating factor for the number of loaded cores C_{gN} to the tabulated current-carrying capacity of the equivalent 2-core cable. When the exact number of loaded cores is not identified in table 4B5, the next higher number of loaded cores is used.



Circuit	Type	Ib	In
1	Lighting	3A	6A
2	Lighting	4A	6A
3	Lighting	5A	6A
4	Lighting	3A	6A
5	Lighting	5A	6A
6	Lighting	5A	6A
7	Lighting	5A	6A
8	Lighting	4A	6A
9	Lighting	4A	6A

Figure 6 - Example of where BS 7671 TABLE 4B5 - rating factors are applicable

Voltage drop & flexible cables

To avoid an over engineered and unreliable system, key aspects to be accounted for include:

- The voltage drop is determined for individual loads, including any line conductors passing through a switch / control device. The total voltage drop being calculated for each part of the circuit respectively.
- Suitable adjustment for reduced conductor temperature, where the design current of a circuit is less than the effective current-carrying capacity of the cable.
- Suitable adjustment for load power factor.
- Suitable adjustment for influence of connector contact resistance.

BS 8488 identifies that prefabricated wiring systems may employ flexible cables, however because the nominal resistance of flexible conductors is higher than that for solid or stranded conductors a suitable factor must be applied when basing the flexible cables on the reference methods in appendix 4.

BS 7671 appendix 4 identifies that to obtain the correct voltage drop for cable types similar to those covered by tables 4D1 etc but with Class 5, flexible conductors, the tabulated values are multiplied by the relevant factor. The factor for cables up to and including 16mm^2 is shown in table 2.

Cable size	Voltage drop factor
≤16.0mm^2	1.10

Table 2

Earth fault loop impedance for protection against electric shock (fault protection)

When Steel Wire Armour is used e.g. home run cable, it is important that a suitable multiplier is applied to its tabulated value of resistance at 20°C. This accounts for the magnetic effect of the steel armour.

Again, the influence of connector contact resistance must be accounted for.

"Account should be taken of voltage drop in each part of the circuit, reduced conductor temperature and connector contact resistance".

Protective conductor cross-sectional area for protection against earth fault current

Where the assumptions of Regulation 435.1 cannot be made, the cross-sectional area of the circuit protective conductors have to meet the adiabatic equation by selection or calculation.

The calculations, should take into account minimum and maximum fault currents, so as to ensure the highest energy let-through (I^2t) is taken into account. This is essential, as I^2t is proportional to the thermal energy let through by the protective device under fault conditions.

"The calculations, should take into account minimum and maximum fault currents".

High protective conductor currents

Regulation 543.7.1.202 stipulates that, when the cumulative protective conductor current of the circuit is likely to exceed 10 mA, it shall have a high integrity protective connection complying with one or more of the five listed options.

Therefore, the designer should evaluate the likely protective conductor currents in relevant parts of the prefabricated wiring system, including those supplying luminaires. This is because it is recognized, that some luminaires can produce currents in the protective conductor e.g. high-frequency fluorescent luminaires. When a significant number of luminaires are supplied from a common system, the protective conductor current may exceed 10 mA. Wherever possible, protective conductor current should be determined by consulting information provided by the luminaire manufacturer.

A protective conductor current not exceeding 10 mA may be difficult to avoid in particular sections of a prefabricated wiring system e.g. the home run cable and link lead to a Lighting Distribution Unit (LDU) therefore, a high integrity protective connection would be required. However, the system arrangement after the home run / LDU link lead could be configured using LDUs supplying a suitable number of luminaires, thus avoiding cumulative protective conductor currents above 10 mA. Table 3 provides examples of luminaire leakage current values.

“A high integrity protective connection may be required”.

Example	Luminaire type	Maximum protective conductor current (mA, r.m.s.)
BS EN 60598-1:2008	Class I intended for permanent connection. Supply current ≤ 7 A.	3.5
Test result for specific luminaire	Fluorescent with HF ballast	0.2
Manufacturers data	Per fluorescent HF ballast	0.5
Manufacturers data	LED driver: output power 150 W	0.7

Table 3 - Examples of leakage current values for conventional luminaires

RCD protected circuits & protective conductor current

The operating range of RCDs is normally from 0,5 $I_{\Delta n}$ to 1 $I_{\Delta n}$. An *international technical report for the correct use of RCDs recommends that, to avoid unwanted tripping, the protective conductor current in a circuit should not exceed 0.3 $I_{\Delta n}$ of the RCD at the rated frequency. For example, this would be a limit of 9 mA protective conductor current for a 30 mA RCD (0.3 x 30 mA = 9 mA).

When RCD protection is employed, the prefabricated wiring system may require appropriate subdivision into several circuits, so as to avoid unwanted tripping.

*PD IEC/TR 62350 Guidance for the correct use of residual current operated protective devices (RCDs) for household and similar use.

Software

“Dedicated calculation software may be essential”.

Calculation software

To avoid an over engineered system and most importantly, have the capability to demonstrate a safe system, dedicated calculation software may be considered essential. One aspect that must not be overlooked is the validity of the approach and calculation methods set out in the specification for the design software. This can be overcome, by specifying that the calculation methods used by the software have been validated by an independent specialist, e.g. ERA Technology Ltd (see figure 7).

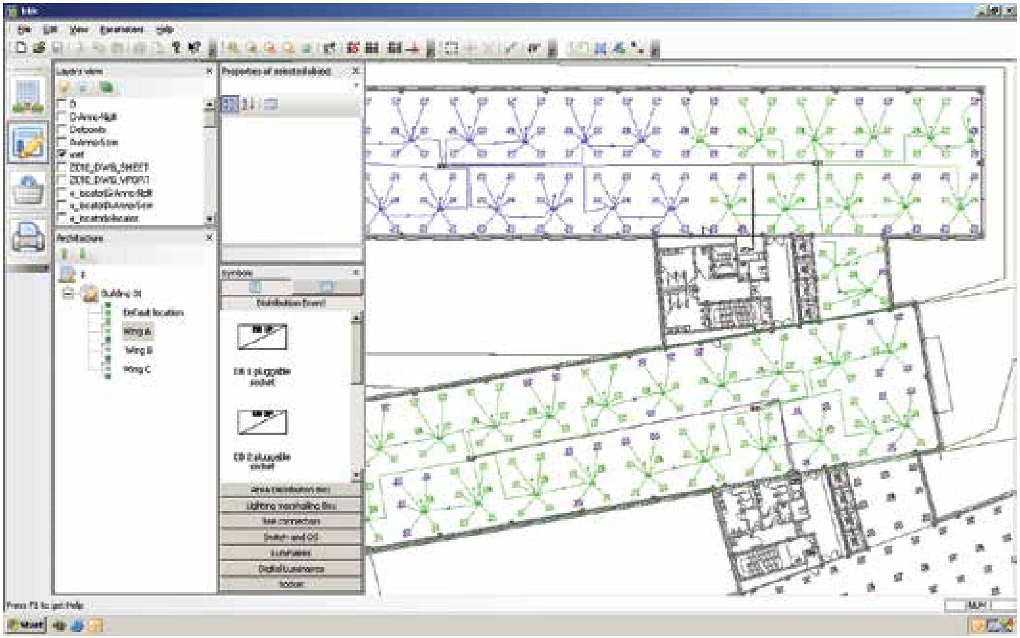
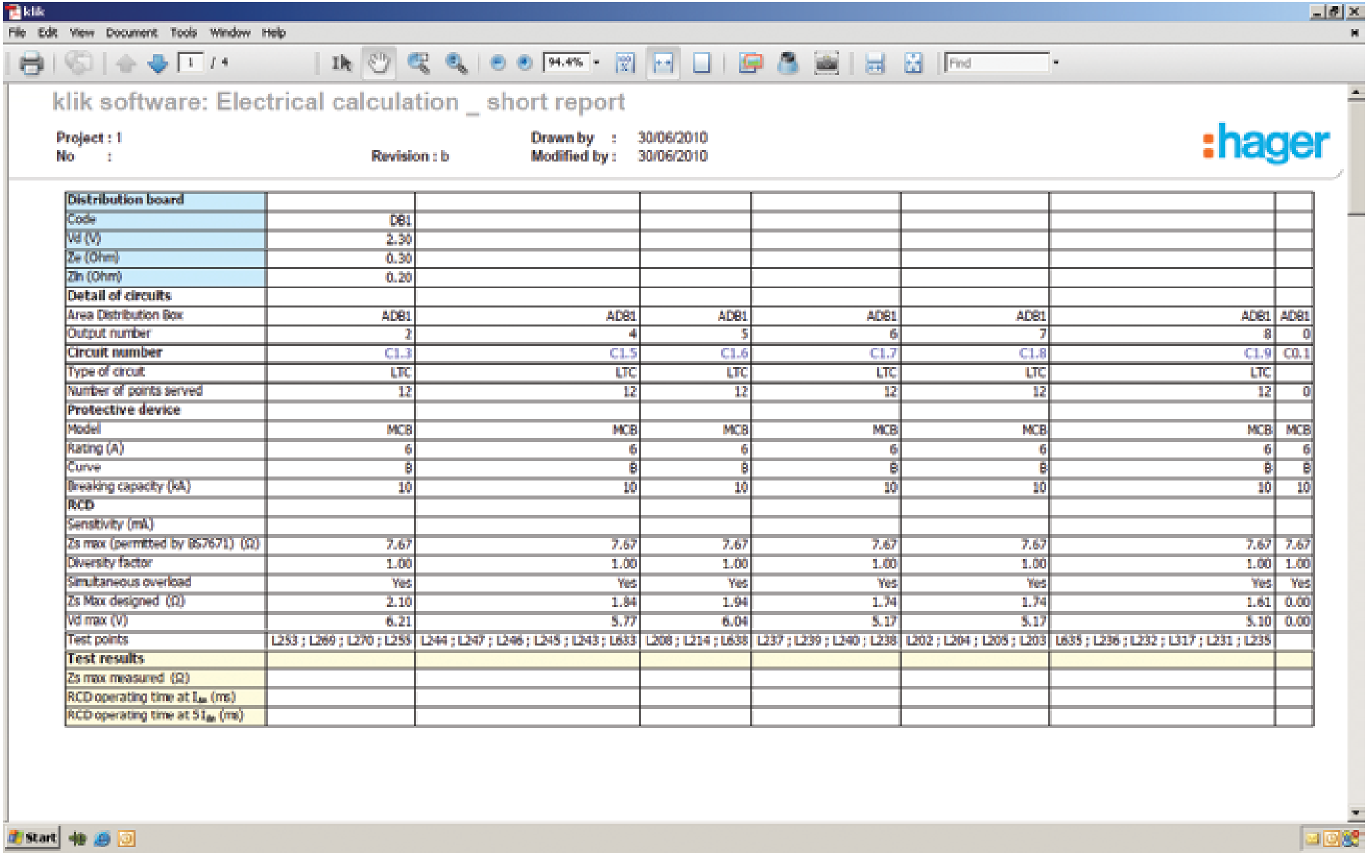


Figure 7 - Example of dedicated calculation software that has been independently validated



klik software: Electrical calculation _ short report

Project : 1
No :
Revision : b
Drawn by : 30/06/2010
Modified by : 30/06/2010

Distribution board							
Code	DB1						
Vd (V)	2.30						
Ze (Ohm)	0.30						
Zln (Ohm)	0.20						
Detail of circuits							
Area Distribution Box	ADB1	ADB1	ADB1	ADB1	ADB1	ADB1	ADB1
Output number	2	4	5	6	7	8	0
Circuit number	C1.3	C1.5	C1.6	C1.7	C1.8	C1.9	C0.1
Type of circuit	LTC	LTC	LTC	LTC	LTC	LTC	
Number of points served	12	12	12	12	12	12	0
Protective device							
Model	MCB	MCB	MCB	MCB	MCB	MCB	MCB
Rating (A)	6	6	6	6	6	6	6
Curve	B	B	B	B	B	B	B
Breaking capacity (kA)	10	10	10	10	10	10	10
RCD							
Sensitivity (mA)							
Zs max (permitted by BS7671) (Ω)	7.67	7.67	7.67	7.67	7.67	7.67	7.67
Diversity factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Simultaneous overload	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zs Max designed (Ω)	2.10	1.84	1.94	1.74	1.74	1.61	0.00
Vd max (V)	6.21	5.77	6.04	5.17	5.17	5.10	0.00
Test points	L253 ; L269 ; L270 ; L255	L244 ; L247 ; L246 ; L245 ; L243 ; L633	L208 ; L214 ; L638	L237 ; L239 ; L240 ; L238	L202 ; L204 ; L205 ; L203	L635 ; L236 ; L232 ; L317 ; L231 ; L235	
Test results							
Zs max measured (Ω)							
RCD operating time at $I_{\Delta n}$ (ms)							
RCD operating time at $5 I_{\Delta n}$ (ms)							

The approach and calculation methods set out in the specification for the Hager klik software has been validated by ERA Technology Ltd (currently trading as Cobham Technical).

System distribution board

BS 8488 specifies that a wiring system comprising a number of circuits connected to separate overcurrent protection shall emanate from an LV switchgear and controlgear assembly, complying with the relevant part of BS EN 61439 or BS EN 61534. An appropriate standard for the system distribution board can be BS EN 61439-3, which is known a distribution board intended to be operated by ordinary persons (DBO).

BS 8488 requires that where the LV switchgear and controlgear assembly contains the wiring system overcurrent protection, the connector to the assembly shall conform to BS EN 61984 and the installation coupler shall conform to BS EN 61535.

In particular, the specifier for the prefabricated wiring system must ensure that LV assembly e.g. distribution board, has suitable ratings that include the incorporated connector and / or installation coupler. For example, conditional fault current rating (short-circuit) and rated current (temperature rise) (see figure 8).

Figure 8 - System distribution board to BS EN 61439-3 with connectors to BS EN 61984.

Area Distribution Box

BS 8488 prescribes the applicable standards for the assembly containing couplers intended for the through connection of circuits that emanate from separate overcurrent protection e.g. circuit-breakers. One example of this arrangement is a multiple circuit distribution cable (known as a home run) originating from a distribution board and terminating at an assembly of couplers (known as an Area Distribution Box "ADB") (see figure 9).

Depending upon the configuration of the assembly of couplers for through connection, BS 8488 requires conformity with BS 5733 or the relevant part of BS EN 61439 or BS EN 61534.

Figure 9 - An assembly of couplers (ADB) complying with BS EN 61439-2

Lighting Distribution Unit

Connection to the fixed wiring

BS 7671 specifies the products that may be used to facilitate connection to each fixed lighting point. A plug-in lighting distribution unit to BS 5733 is identified as an appropriate product, particularly in suspended ceilings, where one plug-in lighting distribution unit may be used for a number of luminaires.

Where a wiring system comprising of a single circuit terminates at an assembly containing couplers intended for branching of a circuit, the assembly is required by BS 8488 to comply with specific standards depending on the assembly designation. Where the assembly containing couplers is specifically designated for the connection of luminaires, it is classified as a lighting distribution unit and must comply with BS 5733 (see figure 10).

Figure 10 - LDU complying with BS 5733:2010

Lighting Distribution Unit safety standard

BS 8488 states that “for dated references, only the edition cited applies.” BS 5733 is dated as 2010. This means that where BS 5733 is specified e.g. “it shall conform to BS 5733 and be classified as a lighting distribution unit as defined in BS 5733” it is a requirement that the product complies with the BS 5733: 2010.

Conformity with BS 5733:2010 is of particular significance for an LDU, as a critical characteristic, is the suitability of the LDU for electrical stresses associated with lighting loads. The amendment to BS 5733 July 2010 acknowledged these stresses and introduced new testing requirements. Therefore, it is a requirement of BS 8488 that an LDU complies with BS 5733: 2010 (see figure 10).

“It is a requirement of BS 8488 that an LDU complies with BS 5733: 2010”.

Installation couplers

BS 8488 requires that prefabricated wiring systems shall incorporate installation couplers that conform to BS EN 61535. (BS EN 61535 has replaced BS 61535). The installation coupler is defined as being not intended to be engaged or disengaged under load or to be engaged or disengaged other than during first installation, during maintenance or during re-configuration of the installation

Installation couplers complying with BS EN 61535 provide confidence that they are designed and constructed so that, in normal use, their performance is reliable and without danger to the user or damage to the surroundings.

BS 8488 lists a number of products that Installation couplers are not intended to be used in place of e.g. luminaire supporting couplers and on load connecting devices to BS 5733.

A prefabricated wiring system will frequently require arrangements to facilitate convenient on-load isolation and switching off for mechanical maintenance of luminaires.

The use of computer controlled luminaires and other automatic lighting control systems has introduced further complications to the safety issues related to isolation and mechanical maintenance. It is essential that the on-load connection device for luminaires is suitable for the prescribed load characteristics e.g. inductive and tungsten loads. A connection device that complies with BS 5733, including its inductive and tungsten load tests would be appropriate.

Therefore, it is an advantage to use a system which provides a convenient on-load connection method that complies with both BS EN 61535 and BS 5733 (see figure 11). However, it is not necessary for the home run distribution connector to be suitable for on-load operation and additionally comply with BS 5733, as home run disconnection is liable to create unacceptable disruption to the system.

Figure 11 - Marking to indicate that an on-load connection method to; BS EN 61535 and BS 5733, provides a convenient luminaire connection method

Hager Ltd.
Hortonwood 50
Telford
Shropshire
TF1 7FT

Internal Sales Hotline: 01952 675612
Internal Sales Faxline: 01952 675645

Technical Helpline: 01952 675689
Technical Faxline: 01952 675557
www.hager.co.uk
info@hager.co.uk **technical@hager.co.uk**

Hager Ltd.
Unit M2
Furry Park Industrial Estate
Swords Road
Santry
Dublin 9
Ireland

Northern Ireland Tel: 028 9077 3310
Northern Ireland Fax: 028 9073 3572

Republic of Ireland Tel: 1890 551 502
Republic of Ireland Fax: 1890 551 503
www.hager.ie

GUIDEKSV311 v2